



U.S. Army Public Health Command (Provisional)

USAPHC

DOD Efforts in Tick Surveillance and Preventing Tick-Borne Disease in the US

U.S. Army Public Health Command

Ellen Stromdahl

Entomological Science Program



UNCLASSIFIED


Tick-borne Disease is an Occupational Health Risk for Military Personnel



Deer on Military Installations





- 
- **Tick and Tick-Borne Disease Surveillance**
 - **Tick Taxonomy / Imaging**
 - **Tick Repellents**

PHC Region-North

Ticks are collected by a variety of methods
 Tick Drag, CO2 trap
 Small, medium, large mammals



SAMPLE INFORMATION		TEST ORGANISM					
Coll'n method	Sample type	Bb #/D/%D	Ec #/D/%D	Ee #/D/%D	Ap #/D/%D	Babesia #/D/%D	Rickettsia #/D/%D
Drag	<i>A. americanum</i>	Non-vector	82/1/1%	82/4/5%	Non-vector	Non-vector	82/0/0%
Drag	<i>D. variabilis</i>	Non-vector	Non-vector	Non-vector	Non-vector	Non-vector	33/0/0%
Drag	<i>I. scapularis</i>	1/0/0%	Non-vector	Non-vector	1/0/0%	1/0/0%	Non-vector
Drag	<i>A. maculatum</i>	Non-vector	Non-vector	Non-vector	Non-vector	Non-vector	2/1/50%¹
Coyote	<i>A. maculatum</i>	Non-vector	Non-vector	Non-vector	Non-vector	Non-vector	2/1/50%¹
Drag	<i>I. affinis</i> ²	3/1/33%	Non-vector	Non-vector	3/0/0%	3/2/67%³	Non-vector

¹ *Rickettsia parkerii* positive causative agent of Tidewater Fever

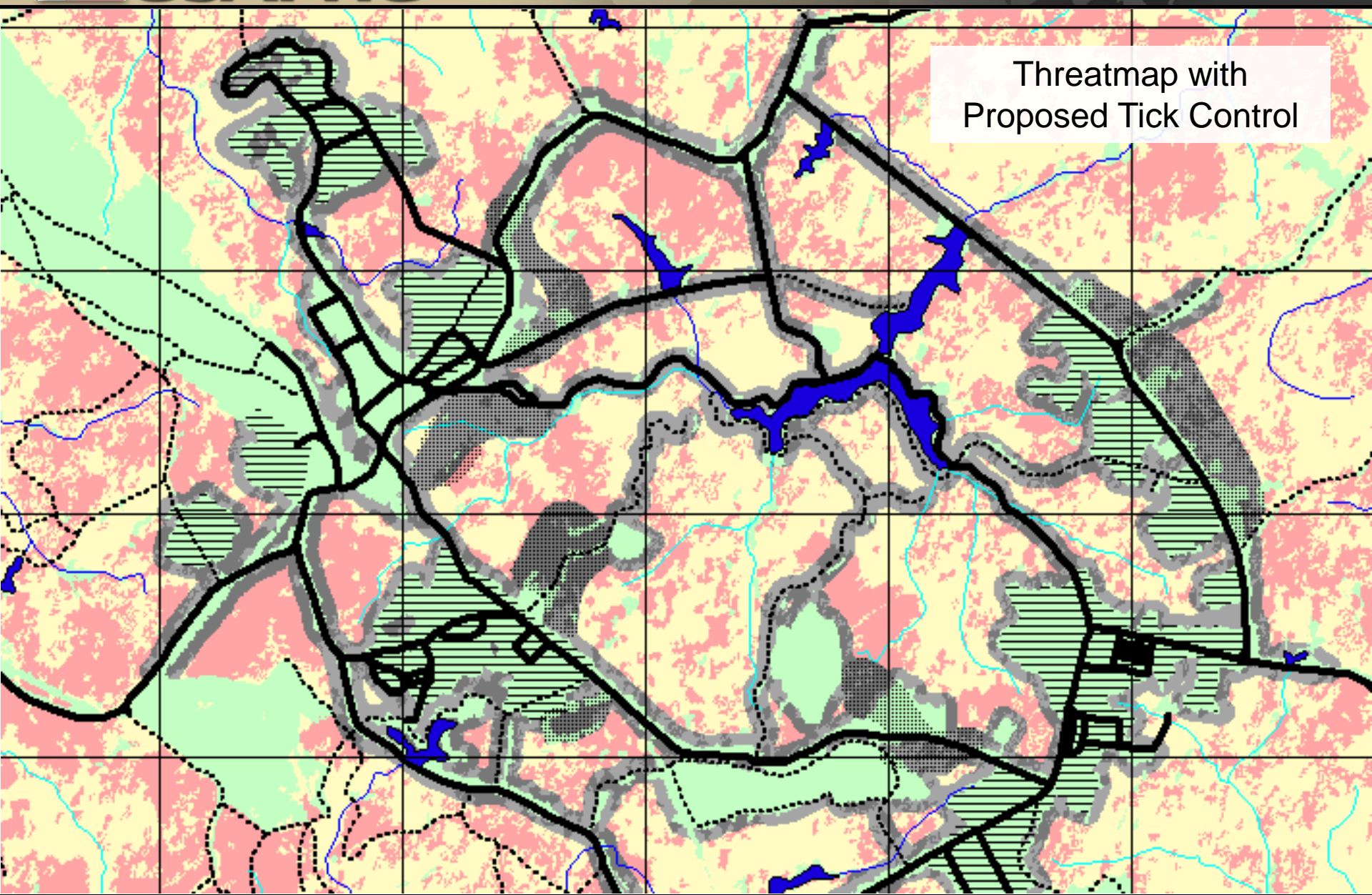
² 5 collected 3 tested 2 submitted to US National Tick Collection as voucher

³ *Babesia canis*



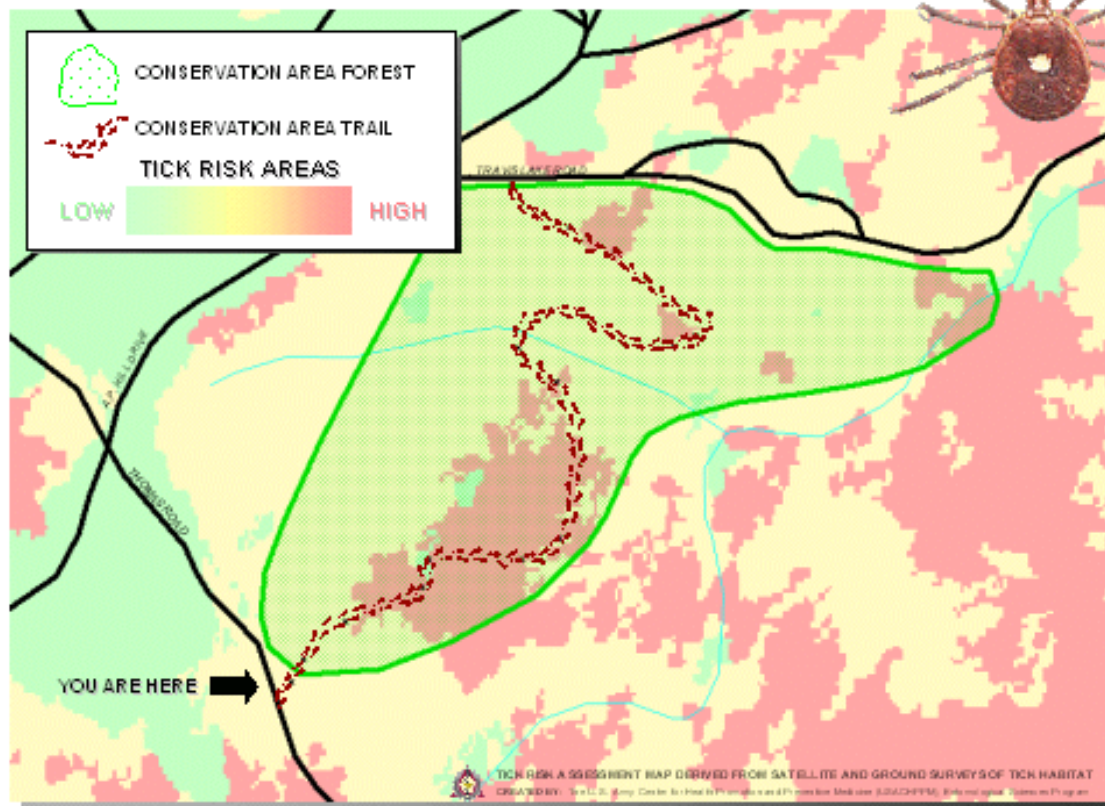


Threatmap with
Proposed Tick Control





BE PREPARED TO ENCOUNTER TICKS ALONG THE CONSERVATION AREA TRAIL



**ALL LOCATIONS
ALONG THE TRAIL
ARE
MEDIUM TO HIGH
TICK RISK AREAS!**

**PROTECT YOURSELF
FROM
TICK-BORNE
DISEASES**

- STAY ON THE TRAIL
- CHECK YOUR SKIN AND CLOTHING FOR TICKS OFTEN; USE THE BUDDY SYSTEM
- USE REPELLENTS; ALWAYS FOLLOW LABEL DIRECTIONS
- ALWAYS SEEK MEDICAL ASSISTANCE TO REMOVE ATTACHED TICKS

REMEMBER...THE BITE OF A TICK CAN MAKE YOU SICK!



Scouts' ticks tested at the Jamboree PHC Region-North



Laboratory identification and PCR analysis during the Jamboree to determine the infection rate of ticks

TICK INFORMATION		TEST RESULTS					
TICK ID	# TICKS TESTED	HME #D (%D)	EE #D (%D)	Rr #D (%D)	Ap #D (%D)	LD #D (%D)	Babesia #D (%D)
<i>A. americanum</i>	124 ¹	3 (2%)	7 (6%)	Non-vector	Non-vector	Non-vector	Non-vector
<i>D. variabilis</i>	161 ²	Non-vector	Non-vector	0 (0%)	Non-vector	Non-vector	Non-vector
<i>I. scapularis</i>	3	Non-vector	Non-vector	Non-vector	0 (0%)	0 (0%)	0 (0%)
TOTAL	288						

DOD Human Tick Test Kit Program

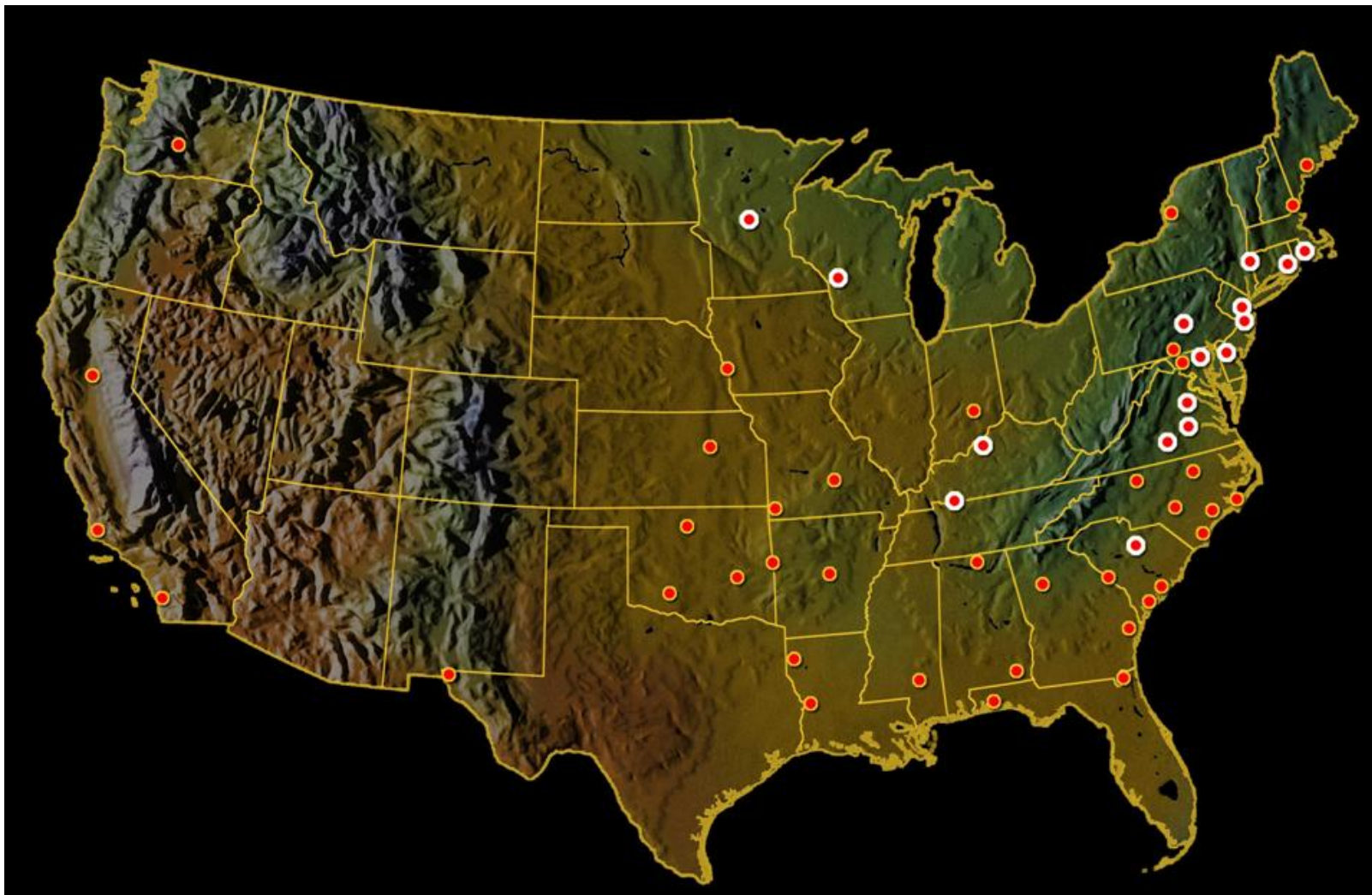
 **Clinical support for health care providers and their tick-bite patients**

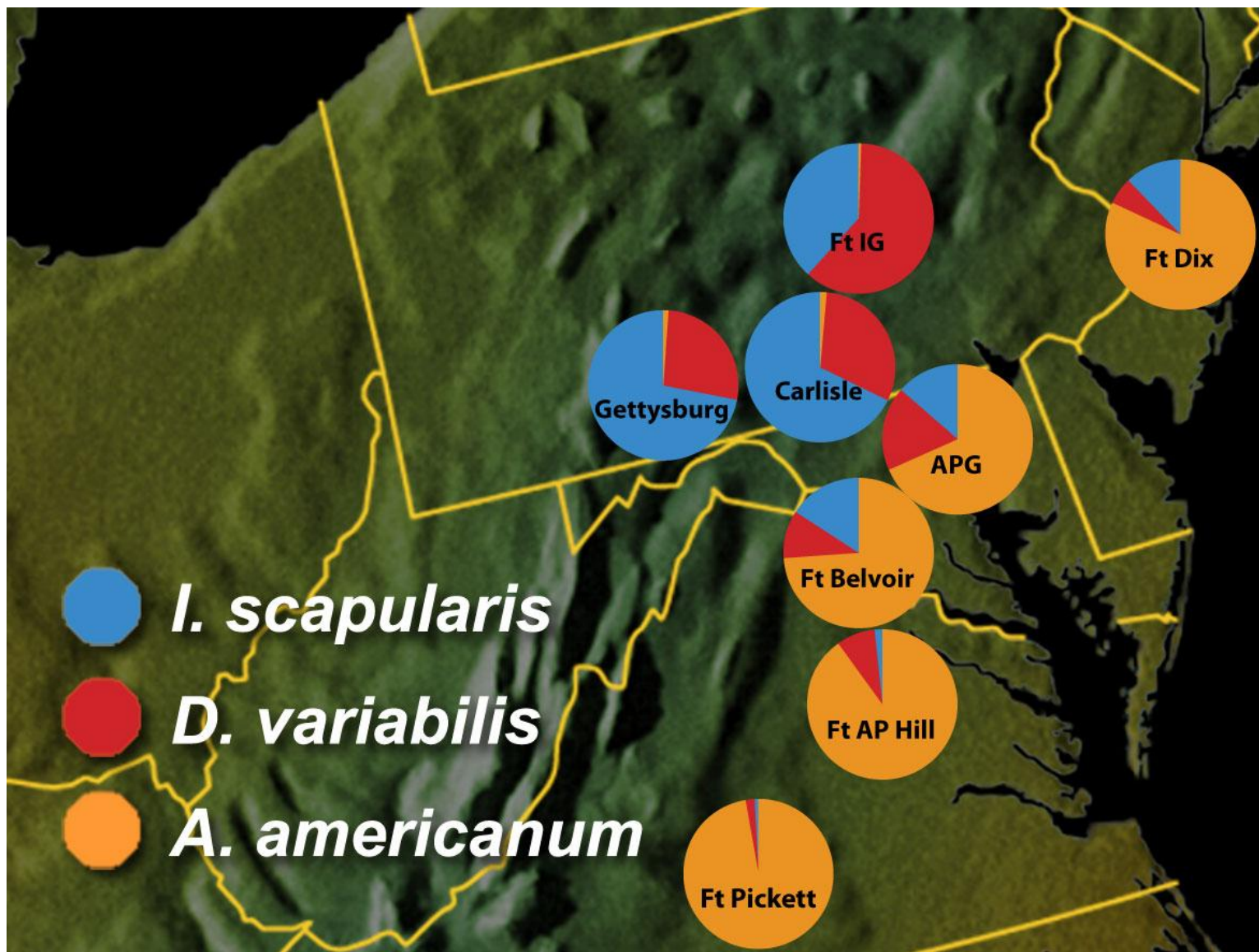
 **Tick I.D. and analysis**

- Lyme disease
- Human granulocytic anaplasmosis
- Babesiosis
- Human monocytic ehrlichiosis
- Ewingii ehrlichiosis
- R. parkeri rickettsiosis
- Rocky Mountain spotted fever



Locations of Tick Test Kit Program Participants





Publications – ticks and tick-borne pathogens

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- Evans SR, Korch GW Jr, Lawson MA. Comparative field evaluation of permethrin and deet-treated military uniforms for personal protection against ticks (Acari). J Med Entomol. 1990 27:829-34.
- Kardatzke, JT, Neidhardt, K, Dzuban, DP Sanchez, JL, et al. Cluster of tick-borne infections at Fort Chaffee, AR: rickettsiae and *Borrelia burgdorferi* in Ixodid ticks. J Med Entomol 1992; 29:669–72.
- Amerasinghe FP, Breisch NL, Azad AF, Gimpel WF, Greco M, Neidhardt K, Pagac B, Piesman J, Sandt J, Scott TW, et al. Distribution, density, and Lyme disease spirochete infection in *Ixodes dammini* (Acari:Ixodidae) on white-tailed deer in Maryland. J Med Entomol. 1992 29:54-61.
- Solberg VB, Neidhardt K, Sardelis MR, Hildebrandt C, Hoffmann FJ, Boobar LR. Quantitative evaluation of sampling methods for *Ixodes dammini* and *Amblyomma americanum* (Acari:Ixodidae) . J Med Entomol. 1992 29:451-6.
- Solberg VB, Neidhardt K, Sardelis MR, Hoffmann FJ, Stevenson R, Boobar LR, Harlan HJ. Field evaluation of two formulations of cyfluthrin for control of *Ixodes dammini* and *Amblyomma americanum* (Acari: Ixodidae). J Med Entomol. 1992 29:634-8.
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- Stromdahl, EY, Evans, SR, O'Brien, JJ, Gutierrez, AG. Prevalence of infection in ticks submitted to the human tick test kit program of the U.S. Army Center for Health Promotion and Preventive Medicine. J Med Entomol 2001; 38:67-74.
- Stromdahl, EY, Williamson, PC, Kollars, TM Jr, Evans, SR, et al. Evidence of *Borrelia lonestari* DNA in *Amblyomma americanum* (Acari: Ixodidae) removed from humans. J Clin Microbiol 2003; 41:5557-5562.
- Sumner, JW, Durden, LA, Goddard, J, Stromdahl, EY, Clark, KL, Reeves, WK and Paddock, CD. A survey of gulf coast ticks (*Amblyomma maculatum*) for *Rickettsia parkeri* in the United States. Emerg Infect Dis. 2007 13:751-3
- Loftis, AD, Mixson, TR, Stromdahl, EY, Yabsley, M J, Garrison, LE, Williamson, PC, Fitak, R R, Fuerst, PA and Blount K.B. Geographic distribution and genetic diversity of the *Ehrlichia* sp. from Panola Mountain. BMC Infect Dis 2008; 8:54
- Stromdahl, EY, Vince, MA, Billingsley, PM, Dobbs, NA, et al. *Rickettsia amblyommii* infecting *Amblyomma americanum* larvae. Vector Borne Zoonotic Dis 2008; 8: 15-24.
- Jiang, J, Yarina, T, Melissa K. Miller, Ellen Y. Stromdahl, Allen L. Richards. Molecular detection of *Rickettsia amblyommii* in *Amblyomma americanum* parasitizing humans. Vector Borne Zoonotic Dis 2010 10:329-40.
- Ellen Y. Stromdahl, Ju Jiang, Mary Vince and Allen L. Richards. Infrequency of *Rickettsia rickettsii* in *Dermacentor variabilis* Removed from Humans. Vector Borne Zoonotic Dis 2010 (Epub ahead of print)
- Eremeeva, ME, Stromdahl, EY. New spotted fever group *Rickettsia* in a *Rhipicephalus turanicus* tick removed from a child in eastern Sicily, Italy. Am J Trop Med Hyg. 2011 84:99-101

Field-portable macro imaging device for arthropod identification

<http://phc.amedd.army.mil/PHC%20Resource%20Library/MacroimagingPortfolio.pdf>



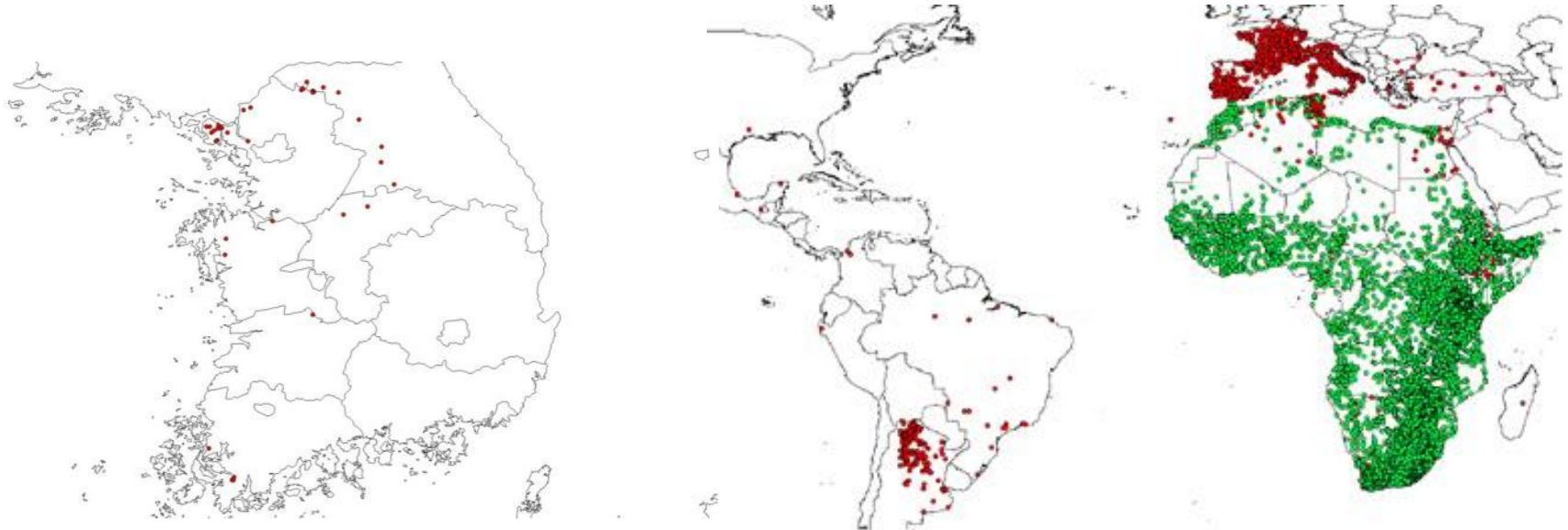
TickMap



TickMap

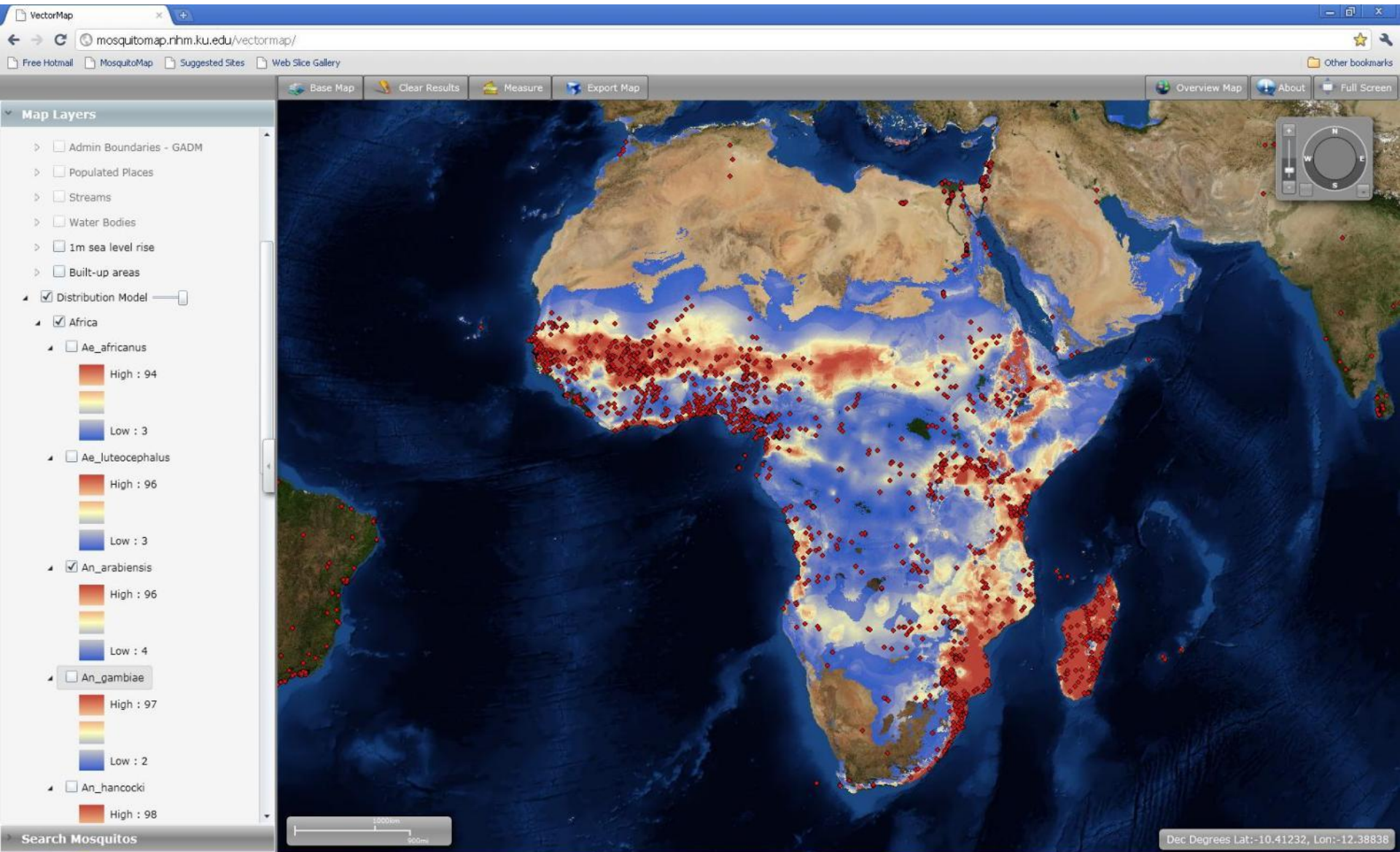


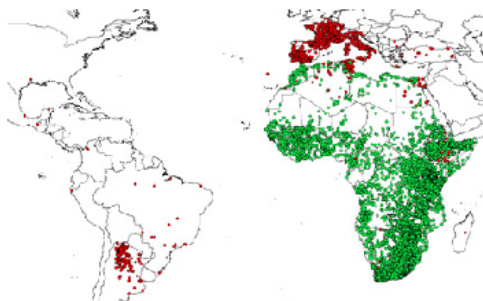
- www.tickmap.org
- Downloadable collection form
- >50,000 records
- New website (requires Silverlight): www.vectormap.org





Relate vector distribution to collection records





MosquitoMap - see [International Journal of Health Geographics](#).

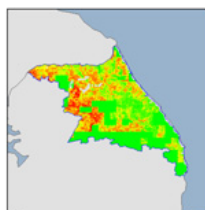
Welcome to TickMap (under construction)!

TickMap is a component of VectorMap - a geospatially referenced clearinghouse for arthropod disease vector species collection records and distribution models. Users can pan and zoom to anywhere in the world to view the locations of past tick collections and the results of modeling that predicts the geographic extent of individual species. Collection records are searchable and downloadable, users can map and upload their own georeferenced collection data or distribution models, and all contributions will have full attribution. Currently, TickMap has **50,194 records**.

TickMap is designed to preserve and make available the results of past collecting and distribution modeling activity. The utility of TickMap will increase as more records and models are added. Contributions are encouraged, especially from individuals and organizations with digitized, georeferenced records and those involved in ongoing mosquito surveillance. TickMap is modeled on

TickMap is useful for:

- informing decisions about where tick collection efforts should be directed
- identifying areas relevant to the study of tick biogeography, evolution and biodiversity
- allow predictions about the potential spread of exotic tick introductions
- allow predictions about the potential effects of global warming on tick distributions
- allow insights into tick community structure, and environmental and climatic correlates to species occurrence (ecological niche)
- allow continent-wide rather than just local studies of vector-borne disease
- identifying cryptic evolutionary lineages that differ in geographic or ecological space.



The Mal-area calculator

A novel enhancement of TickMap is the Mal-area calculator (MAC) that quantifies the overlap between vector and pathogen distribution models, and host (human) population. The co-occurrence of vectors, parasites and hosts are required for many vector-borne diseases, and the MAC quantifies this co-occurrence for a given area, thus potentially providing a map and simple index of disease risk for any area of interest. At the moment the MAC is at the 'proof of concept' stage, and only works in MosquitoMap for South Korea, but we plan to expand its coverage in the near future!

OPEN DATA PORTAL (under construction)

Funding for TickMap was provided by the US Department of Defense Global Emerging Infections Surveillance and Response System(DoD-GEIS), a Division of the Armed Forces Health Surveillance Center, and from the Global Biodiversity Information System (GBIF). Comments and questions should be directed to [Desmond Foley](#), [Pollie Rueda](#) and [Richard Wilkerson](#), or by visiting the [FORUM](#).

Website updated on 06/17/2010 16:11.

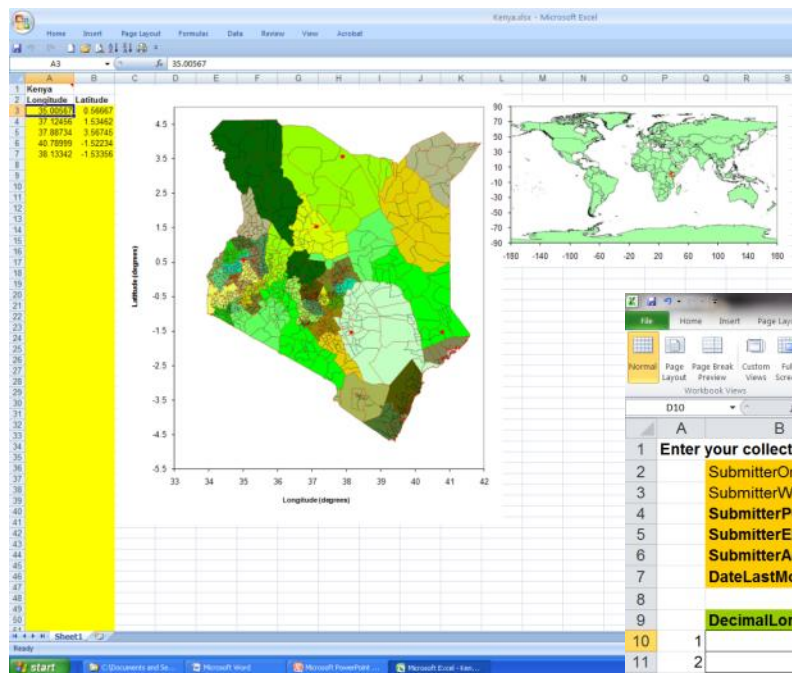


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How to contribute collection records

Excel Mapper



Collection forms

DecimalLongitude	DecimalLatitude	Species	Collector	DateOfCollection	BasisOfRecord	CollectionCode
1		varuna, Anopheles, Cella, Iyengar 1924				
2		varuna, Anopheles, Cella, Iyengar 1924				
3		vattieri, Culex, Eumelanomyia, G				
4		vaxus, Culex, Melanoconion, Dye				
5		veeniae, Aedes, Aedimorphus, M				
6		venezuelensis, Coquillettia, Rh				
7		ventriloni, Culex, Culex, Edward				
8		ventrovittis, Aedes, Ochlerotatus				
9		venustipes, Aedeomyia, Aedeom				



Timely data and analysis
for today's military
health decision makers



Armed Forces Health Surveillance Center



MSMR

A publication of the Armed Forces Health Surveillance Center



MEDICAL SURVEILLANCE
MONTHLY REPORT

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Read the MSMR online at: <http://www.afhsc.mil>

Lyme disease among U.S. military members, Active and Reserve Component, 2001-2008

Lyme disease is a zoonotic tick-borne disease that is caused by infection with a spirochetal bacterium of the genus *Borrelia*. It has a worldwide distribution and is endemic in many temperate regions of the northern hemisphere. In the United States, it is hyperendemic along the mid- and northeastern Atlantic seaboard and in nonurban areas of Wisconsin.^{1,4}

Lyme disease is transmitted by ticks that feed on both humans and animal hosts of *Borrelia* (e.g., deer, mice, raccoons). *Borrelia* are usually transmitted to humans during blood meals of ticks in the nymphal stages of their life cycle. Nymphal stage ticks are very small (approximately the size of poppyseeds); hence, they often feed undetected for the time required to transmit infection (24-48 hours). In the United States, the 'deer tick' (*Ixodes scapularis*) and western black-legged tick (*Ixodes pacificus*) are competent vectors of Lyme disease.^{1,4}

The clinical manifestations and courses of Lyme disease are highly variable. The time from infection to initial symptoms is generally 7-14 days (range: 3 to >30 days). The presenting manifestation of Lyme disease is often a slowly enlarging, centrally clearing ('bull's-eye') rash at the site of the infecting tick bite (erythema migrans). While erythema migrans is a distinctive characteristic of Lyme disease, it occurs in only 60-80% of cases. Other early manifestations are non-specific and include fever, headache, muscle aches, joint pains, lymphadenopathy, malaise, and fatigue. Without effective antibiotic treatment, acute symptoms can persist for weeks or more. Weeks to months after infection, clinical manifestations of inflammation of the joints, nervous system

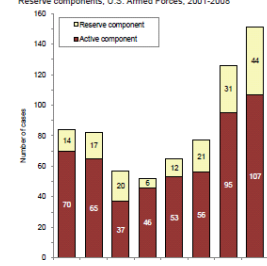
(e.g., facial palsy, encephalitis), and heart (e.g., conduction abnormalities) can occur. Most cases are effectively treated with single courses of antibiotics.^{1,4,5}

Many military activities are conducted in tick-infested areas. In such settings, personal protective measures (e.g., use of DEET-containing insect repellents, proper wear of permethrin-treated uniforms, frequent inspections for and prompt identification and removal of ticks) are essential for disease prevention. This report summarizes incident diagnoses and medical event reports of Lyme disease among U.S. military members from 2001 through 2008.

Methods:

The surveillance period was 1 January 2001 to 31 December 2008. The surveillance population included all active and Reserve component members of the U.S. Armed Forces. All data were derived from inpatient, outpatient, and reportable medical event records maintained in the Defense Medical Surveillance System (DMSS). For surveillance purposes, a 'confirmed case' of Lyme disease was defined by a hospitalization with a diagnosis of 'Lyme disease' (ICD-9-CM:088.81) in any of the first three diagnostic positions; a notifiable medical event report of Lyme disease or at least

Figure 1. Confirmed cases* of Lyme disease, active and Reserve components, U.S. Armed Forces, 2001-2008



*Hospitalization (dx=1-3), notifiable event report or at least 3 ambulatory visits (dx1) separated by at least 7 days with a diagnosis of 'Lyme disease' (ICD-9-CM: 088.81)
*One or more ambulatory visits that did not meet the 'confirmed case' definition.

Confirmed cases are defined as hospitalizations (dx=1-3), notifiable event reports or at least three ambulatory visits (dx1) separated by at least 7 days with a diagnosis of 'Lyme disease' (ICD-9-CM: 088.81)

www.afhsc.mil/msmr



*Timely data and analysis
for today's military
health decision makers*

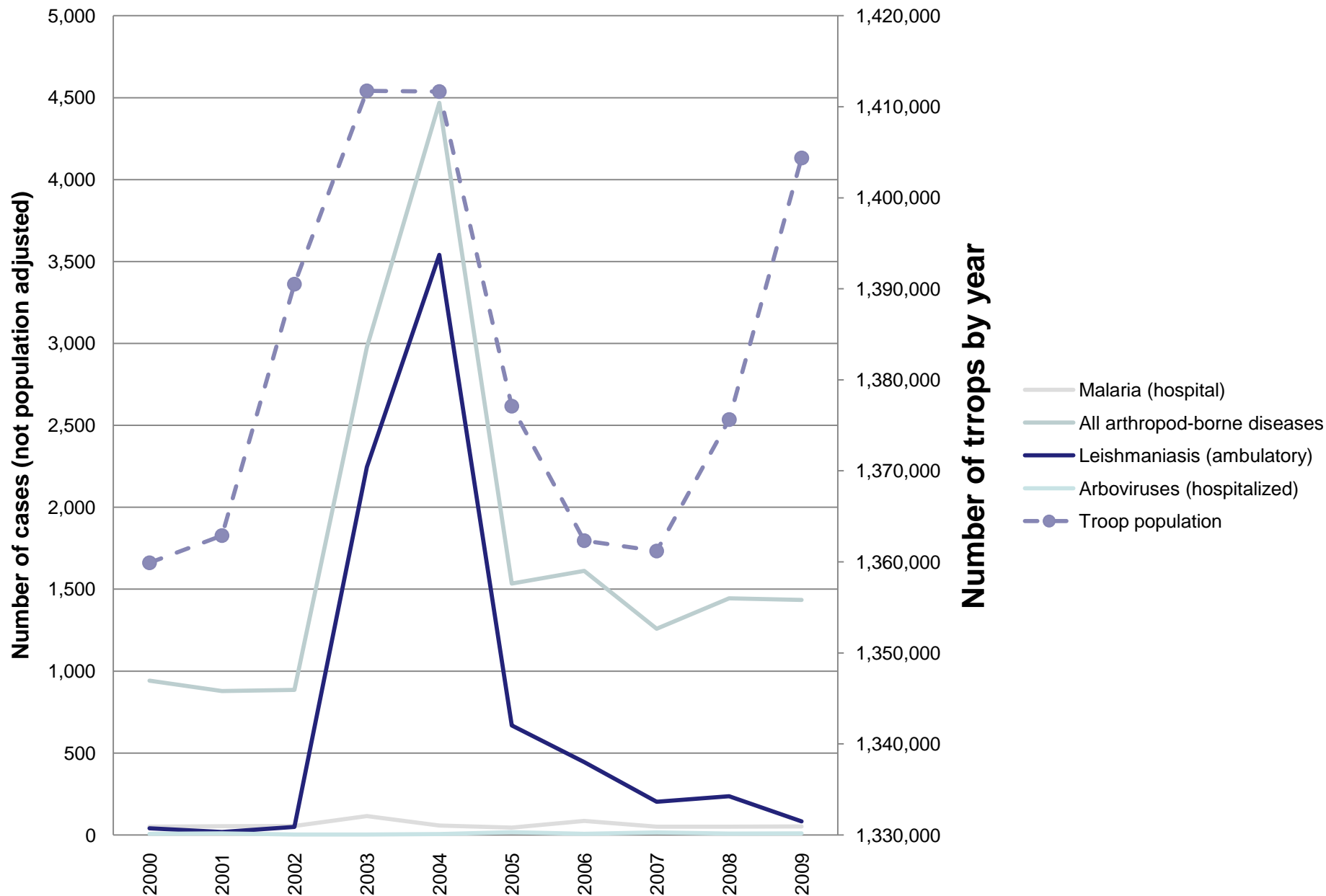


Armed Forces Health Surveillance Center

Defense Medical Epidemiology Database:

<http://www.afhsc.mil/aboutDmed>

Reported cases of various vector-borne diseases in the military 2000-2009 (source AFHSC's DMED website)



DEVELOPMENT OF MOLECULAR ASSAYS FOR DETECTING TICK-BORNE PATHOGENS





Quantitative real-time PCR(qPCR) assays

qPCR assays for detection of *Rickettsia* in ticks

Rickettsia genus assay-Rick17b

tick-borne spotted fever group assay-Trick

species specific assays:

R. rickettsii-Rrick

R. parkeri-Rpark

Candidatus R. andeanae-Rande

R. felis-Rfelis

R. montanensis -Rmont

R. amblyommii-Rambl

R. conorii-Rcono

R. africa-Rafri

R. raoultii-Rraou

R. slovaca-Rslov

R. aeschlimannii-Raesc

qPCR assays available for detection of other tick-borne pathogens

Borrelia lonestari

Borrelia burgdorferi

Ehrlichia chaffeensis

E. canis

Anaplasma phagocytophilum

Coxiella burnetii

qPCR assays available for identification of tick species

Amblyomma americanum

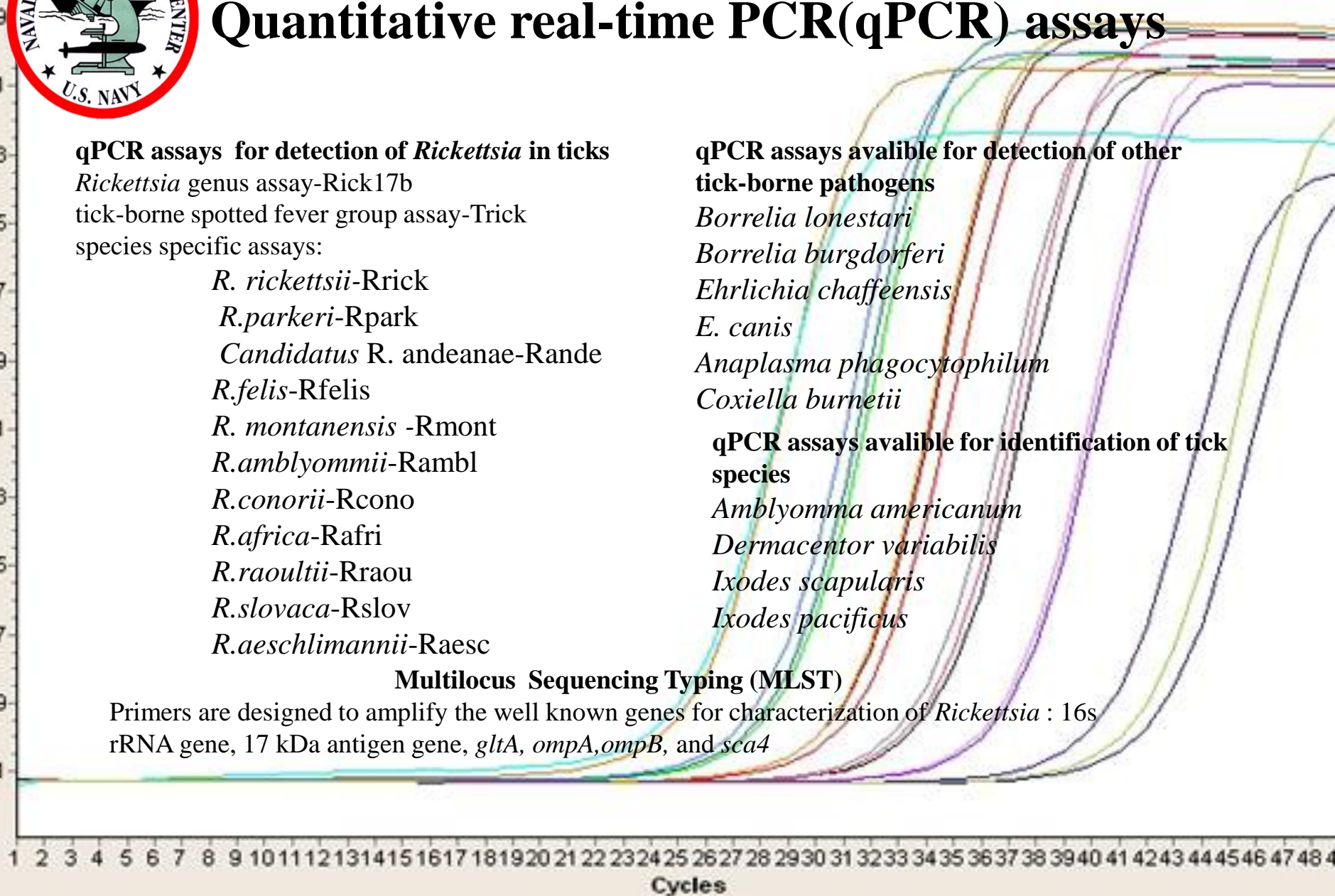
Dermacentor variabilis

Ixodes scapularis

Ixodes pacificus

Multilocus Sequencing Typing (MLST)

Primers are designed to amplify the well known genes for characterization of *Rickettsia* : 16s rRNA gene, 17 kDa antigen gene, *gltA*, *ompA*, *ompB*, and *sca4*





Publications - detection of tick-borne pathogens

- Stromdahl EY, Jiang J, Vince M, Richards AL. Infrequency of *Rickettsia rickettsii* in *Dermacentor variabilis* removed from humans, with comments on the role of other human-biting ticks associated with spotted fever group rickettsiae in the United States. Vector Borne Zoonotic Dis 2010 (Epub ahead of print)
- Smith MP, Ponnusamy L, Jiang J, Ayyash LA, Richards AL, Apperson CS. Bacterial pathogens in ixodid ticks from a Piedmont County in North Carolina: prevalence of rickettsial organisms. Vector Borne Zoonotic Dis. 2010 Dec;10(10):939-52
- Jiang J, Yarina T, Miller MK, Stromdahl EY, Richards AL. Molecular Detection of *Rickettsia amblyommii* in *Amblyomma americanum* Parasitizing Humans. Vector Borne Zoonotic Dis 2010 May;10(4):329-40.
- Whitman TJ, Richards AL, Paddock CD, Tamminga CL, Snizek PJ, Jiang J, Byers DK, Sanders JW. *Rickettsia parkeri* infection after tick bite, Virginia. Emerg Infect Dis 2007;13(2):334-6.
- Wright CL, Nadolny RM, Jiang J, Richards AL, Sonenshine DE, Gaff HD, Hynes WL. *R. parkeri* found in *A. maculatum* from VA. Emerg Infect Dis 2011
- Jiang J, Stromdahl EY, Richards AL. Detection of *Rickettsia parkeri* and *Candidatus Rickettsia andeanae* in *Amblyomma maculatum* Gulf Coast Ticks Collected from Humans in the United States. Vector Borne Zoonotic Dis (submitted)
- Rozmajzl PJ, Flyer JG, Jiang J, Stromdahl EY, and Richards AL. Development of a Quantitative Real-time Polymerase Chain Reaction (qPCR) Assay for the Detection of *Rickettsia montanensis* Validated with *Dermacentor variabilis* Collected from Humans. Am J Trop Med Hyg. 2011 (submitted)
- Truong M, Jiang J; Yarina T, Evans H, Turner J, Miller M, Christensen TP, Richards AL. *Rickettsia parkeri* and *Ehrlichia chaffeensis* Detected in Ixodidae Ticks from Fort Eustis, Virginia. Am J Trop Med Hyg. 2011 (submitted)



Prevalence and Clinical Characteristics of
Infection Caused by the Newly Emerging
Pathogen, *Rickettsia parkeri*, in Adults
and Children Presenting to Clinics and
Emergency Departments with Acute
Febrile Illness.

Todd Myers, PhD
Naval Medical Research Center
Silver Spring MD



U.S. Army Public Health Command (Provisional)

USAPHC



+



**TICK TESTING &
HUMAN DIAGNOSTICS**



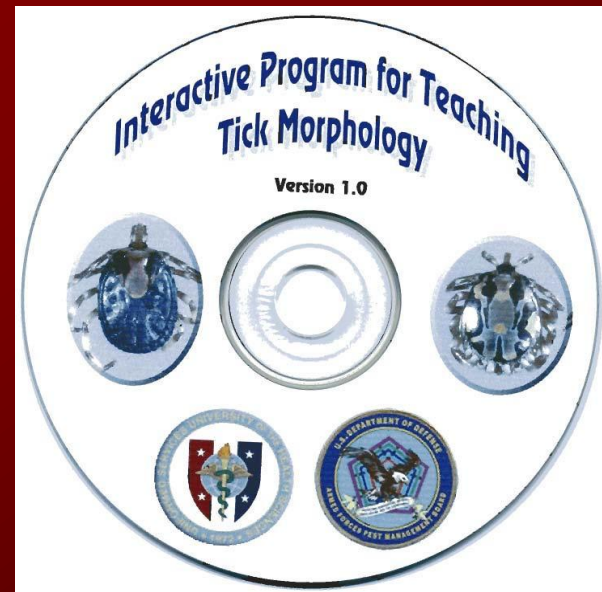
ARMED FORCES PEST MANAGEMENT BOARD

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LITERATURE RETRIEVAL SYSTEM



DVD ON TICK IDENTIFICATION





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IMAGE LIBRARY



Dr. Henry Hoogstraal



DoD Insect Repellent System



Military

Commercial

0.5% PERMETHRIN Aerosol Spray Can NSN 6840-01-278-1336



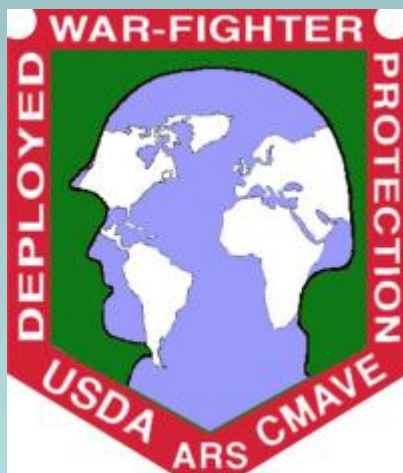
PERMETHRIN Impregnation (IDA) Kit

NSN 6840-01-345-0237



PERMETHRIN Application using 2-Gallon Sprayer







Deployed War-Fighter Protection (DWFP) is a DOD-sponsored research program administered by the [Armed Forces Pest Management Board \(AFPMB\)](#).

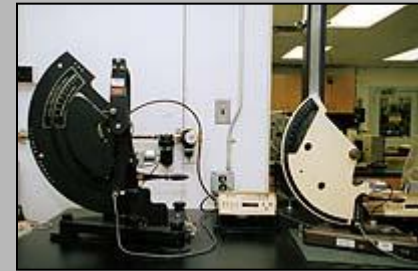


USDA ARS CMAVE has developed a test procedure to ensure military uniforms are correctly treated to protect troops from arthropod bites.





NSRDEC US Army Natick Soldier Research, Development & Engineering Center





Permethrin Factory-Treated Flame Resistant Army Combat Uniforms (FRACU-P)





Permethrin Factory-Treated Flame Resistant MultiCam Uniforms (Afghanistan)





U.S. Army Public Health Command Ellen Stromdahl Tick-Borne Disease Laboratory

The views expressed in this article are those of the author and do not reflect the official policy or position of the Department of the Army, Department of Defense or the U.S. Government.